SAHTU SETTLEMENT AREA
GIS PROJECT
JULY 1996 – JULY 1998

Northwest Territories Resources, Wildlife & Economic Development

SAHTU SETTLEMENT AREA
GIS PROJECT
JULY 1996 – JULY 1998

ALASDAIR VEITCH

DEPARTMENT OF RESOURCES, WILDLIFE AND
ECONOMIC DEVELOPMENT
GOVERNMENT OF THE NORTH WEST TERRITORIES
NORMAN WELLS, NWT

AND

LANA LEVERINGTON
SAHTU RENEWABLE RESOURCES BOARD
NORMAN WELL, NWT

1999

Manuscript Report No. 111

THE CONTENTS OF THIS PAPER
ARE THE SOLE RESPONSIBILITY OF THE AUTHOR

GNWT - Resources Wildlife & Economic Development
Received
#_____
SEP - 3 1998
DIRECTOR OF
WILDLIFE & FISHERIES

SAHTU SETTLEMENT AREA GIS PROJECT July 1996 to July 1998

Prepared By:

Alasdair Veitch
Supervisor, Wildlife Management[1]

Lana Leverington
GIS Specialist[2]

[1] Dept. of Resources, Wildlife, and Economic Development
Norman Wells, NWT

[2] Sahtu Renewable Resources Board
Norman Wells, NWT

August 1998

ABSTRACT

By combining data from many different sources, GIS enables effective management of large land areas. The Sahtu Settlement Area GIS Project aims to involve co-management boards set up under the Sahtu Dene and Metis Comprehensive Land Claim Agreement; community councils, corporations and other organizations; and the Government of the Northwest Territories in a common project that will develop a GIS for resource management within the Sahtu Settlement Area. This document provides a background and overview of the project's activities to date.

103-06861/

TABLE OF CONTENTS

INTRODUCTION 2

OBJECTIVE 4

RATIONALE 4

PROGRESS – JULY 1996 TO JULY 1998 6

DATA LAYERS COMPILED 8

WORK DONE FOR OTHER ORGANIZATIONS 10

STEERING COMMITTEE 11

BUDGET 12

REFERENCES 14

APPENDIX 1: Project Expenditures: 1997/98 and 1998/99 15

APPENDIX 2: Vegetation classification project 16

APPENDIX 3: Cost of 'desktop' GIS systems 20

APPENDIX 4: Data Layers of the GIS 21

INTRODUCTION

Geographic information systems (GIS) were first used in the management of natural resources in 1969 (Koeln et al. 1994) and over the last three decades they have become central to most resource management agencies and organizations. GIS provide resource users and managers the ability to combine data from many different sources: fish and wildlife, vegetation, watersheds, human use and occupation, non-renewable resources, climate, etc. This enables effective management of large land areas and allows us to include the needs of people, along with those of plants, animals, and the environment in which they live.

A GIS is essentially a set of computer hardware and software that allows us to store maps, and collections of information (databases) about those maps, so that we can display and analyze geographic data. However, the real power of a GIS is to answer specific questions and to allow users to make predictions about what might occur at a specific place as a result of some activity. For example, we might want to use GIS to help choose the best location for a new territorial park in the Sahtu. The people wishing to establish the park want it to have the following characteristics: about 1000 km^2 in size, have Dall's sheep, be accessible by boat, on public lands, not be located within an important subsistence harvesting area, and not used for industrial activities. A GIS with the appropriate data can readily show the areas that meet all of these requirements, which will then help us make the best decision on where to locate the park.

There are four basic questions GIS are normally used to answer (Koeln et al. 1994).

1) *What exists at a certain site or location?*
2) *Where are certain conditions met?*
3) *What changes have occurred over time and where have these changes occurred?*
4) *What are the social, economic, or environmental impacts of a change in the use of the land?*

The following are some of the types of tasks that could involve use of the Sahtu GIS Project. The list indicates the need for integrated resource management, since the data are collected by foresters, subsistence harvesters, hydrologists, geographers, anthropologists, land and water use planners, wildlife and fishery biologists, and people in industry.

- provide a storehouse for traditional knowledge (TK) and a means to relate it to specific geographic areas.
- map potential areas for some type of protection (e.g., sacred sites and heritage sites).
- assist with forest resource inventory, including distribution of harvestable hardwood and softwood stands by classification of vegetation from satellite imagery.
- preparation of fire history maps and providing a storehouse for community values-at-risk information, which will help in development of comprehensive forest fire management plans for Sahtu communities.
- maintain a record of permafrost depth and distribution around communities to help predict possible effects of global warming.
- map lakes with high levels of mercury, arsenic, or other potentially harmful contaminants.
- maintain a forest disease inventory.
- prepare development and management plans for community, territorial, and national parks.
- provide a detailed description of current subsistence harvest patterns and locations from the Sahtu Settlement Harvest Study to assist with community-based management of harvested species and to assist with assessing possible impacts on renewable resource harvest from proposed developments (e.g., land use permit process)
- provide a means (e.g., maps, tables, data files) to distribute TK to other communities and jurisdictions.
- produce high-quality, detailed maps for use by schools, tourists, park managers, community, district, and regional planning authorities, and those responsible for natural resource management and enforcement.

In this Project Outline we provide the rationale, background, data layers, methods, and budget for a project that will meet the current and future GIS needs in the Sahtu communities. The development and direction of the project is constantly evolving, and we anticipate that changes will occur as new players come on board and as new technologies become available. This document provides a background and overview of the project's activities to date. We welcome suggestions, comments, questions, and critiques from any interested individuals and organizations.

OBJECTIVE

To involve co-management boards set up under the Sahtu Dene and Metis Comprehensive Land Claim Agreement (1993); community councils, corporations, and other organizations; and the Government of the Northwest Territories in a common project that will develop a GIS for resource management within the Sahtu Settlement Area.

RATIONALE

The Sahtu is a large region (283,000 km^2) of varied habitats, including the Mackenzie Mountains, the Mackenzie River Valley, large tracts of boreal forest, Great Bear Lake, and tundra in the north-east. It has the most diverse assemblage of terrestrial wildlife species in northern Canada, on which people depend for subsistence, outfitted sport hunting, and trapping. Several species of fish are extensively harvested in both domestic and commercial fisheries. There is current and potential development in oil and gas, mining, tourism, and transportation - all of which could affect fish, wildlife, and their habitats, and people's activities on the land. Therefore, we need a way to collect and store information that can be used in decision-making about proposed industrial activity, in fishery and wildlife management, and community development. An accurate, well-documented, and well-planned GIS project provides this.

Maps serve as a common language among people in the communities, researchers and technical experts, people in industry, and government. Such a common language is vital when these groups work together to make decisions about management of land, fish and wildlife, water, and industrial or other developments. Language is often a distinct barrier between the technical people that collect, analyse, and present data and the people in local communities that are most in need of the information (Lewis 1995). Anything that serves to reduce or eliminate these barriers will help involve more people in guiding the future development and nature of the Sahtu.

The *Sahtu Dene and Metis Comprehensive Land Claim Final Agreement* (1993) created various community and District councils and corporations, and co-management boards with responsibility for natural resource management within the Sahtu, along with the ongoing responsibilities of the governments of the Northwest Territories and Canada. For example, under the terms of *The Mackenzie Valley Resource Management Act*, the Sahtu Land and Water Board (SLWB) will be responsible for issuing land and water use permits within the Sahtu and the Land Use Planning Board (SLUPB) is responsible for developing a settlement area Land Use Plan. In addition, the Sahtu Renewable Resources Board (SRRB) is identified in the Land Claim as the "main instrument for wildlife management" within the region. Given this, and the proven ability of GIS to be effective in community-based resource management over large areas (Franklin 1994; Lewis 1995), we have the ideal opportunity to implement a GIS project for the benefit of all individuals and organizations with responsibility for natural resource management in the Sahtu.

PROGRESS - JULY 1996 to JULY 1998

The first GIS in the Sahtu was installed in the former Dept. of Renewable Resources (now Dept. of Resources, Wildlife, and Economic Development - DRWED) Sahtu Region Office in 1991 and was operated by Wildlife Management staff. That GIS used *SPANS* software and it served the rather limited needs of Wildlife Management until the summer of 1996, when rapidly increasing demands and requirements made a new system necessary.

Veitch and Leverington developed the idea for a GIS project for the Sahtu in the summer of 1996. The main objective of the initial project outline (Veitch 1996) was for a single GIS project that could meet the present and future GIS needs of co-management boards and the GNWT, rather than each developing their own independent GIS projects. The goal was to eliminate duplication and unnecessary costs.

A proposal for the GIS Project was presented by Veitch and Leverington to the Sahtu Renewable Resources Board in October 1996. The SRRB endorsed the project and agreed to fund most of the project's start up costs. In February 1997 the SRRB agreed to be the major funding co-management board for the project for the 1997-1998 fiscal year, provided the other co-management boards be asked to contribute once they were set up and had funding capabilities.

Leverington was hired as the project's GIS Specialist in February 1997 by the SRRB, with joint supervision by the Executive Director of the SRRB and Veitch. Veitch remained Project Co-ordinator and the project was based in the DRWED Sahtu Region Office in Norman Wells.

In December 1996 the GIS project outline was presented to the Sahtu Land and Water Board Working Group in Norman Wells. The SLWB showed considerable interest in the project and its objectives; however, the SLWB felt that it did not then have its GIS needs identified and wished to determine their requirements and explore available options.

New system hardware for the project was purchased by the SRRB in January 1997 with specifications recommended by DRWED's Forest Management Division (Fort Smith). A colour plotter for large-format maps, laser printer, *Polaroid* slide-maker for instant colour slides, a digitizing table, telephone, electronic mail, office space, and furniture were provided by DRWED (Sahtu Region).

ARC/INFO software was purchased in March 1997 by the SRRB through a standing offer agreement between the GNWT and *ESRI Canada*. *ARC/INFO* is the most widely used GIS software in North America (Crockett 1997) and most databases created by outside suppliers are available in *ARC/INFO* format.

ARC/INFO runs with the companion software package, *ArcView*, which allows people without formal training in GIS to use GIS-format data files to which they have been given access and produce their own maps. Our goal is to have staff with each of the co-management boards and other interested regional organizations trained in use of *ArcView* so that each can use and display information for their needs from files produced by the main GIS project. This will save considerable time, money, and effort as opposed to having the GIS Specialist producing all hard copy products required. It will certainly save money compared to each board hiring their own GIS Specialist with associated hardware and software requirements.

In March 1997 a copy of *ArcView* was purchased for the project by Forest Management (Fort Smith) along with a complete set of digital 1:250,000 scale topographical base maps of the Sahtu, digital forest fire history of the western NWT, and values-at-risk for the Sahtu's forested lands. The digital topographical maps are simply a computer format of the familiar Canada National Topographic System (NTS) maps that can be purchased at outlets across the NWT.

In November 1997 a new computer, colour printer, and copy of *ArcView* were purchased for the GIS Project with funds from Forest Management (Fort Smith). This computer is the same as the 'desktop' GIS systems that we propose for each co-management board. This system was

extensively used in preparation and production of maps for the Sahtu Settlement Harvest Study and LANDSAT images for the Vegetation Classification Project (Appendix 2).

Since May 1997, the GIS Project has been fully operational and has produced maps and other products for contributing agencies and outside groups. Considerable time has been spent searching for and purchasing data, organizing data layers, and formatting maps for output. Next we provide an overview of some of this work.

DATA LAYERS COMPILED

Base Map – organized 1: 250,000 scale digital base maps (National Topographic System) received from Forest Management (Fort Smith). Include lakes, rivers, and other water bodies; elevation; roads and cutlines; communities, and other data shown on standard hard copy NTS maps.

Sahtu Dene and Metis Selected Lands – organized and mapped data files received from the Legal Surveys Division of Geomatics Canada (Natural Resources Canada, Yellowknife) showing boundaries of Sahtu Dene and Metis selected surface and subsurface rights land parcels, as described in the Land Claim.

Special Harvesting Areas - created a digital database file for Special Harvesting Areas of the Sahtu Dene and Metis for fish, moose, and migratory game birds as described in the Land Claim.

Dene and Metis Traditional Trails – purchased a database of traditional trails of Dene and Metis in the western NWT as recorded in the 1970's by the Dene Cultural Institute and digitized by University of Alberta. Overlaid the trails on the 1:250,000 base maps for distribution.

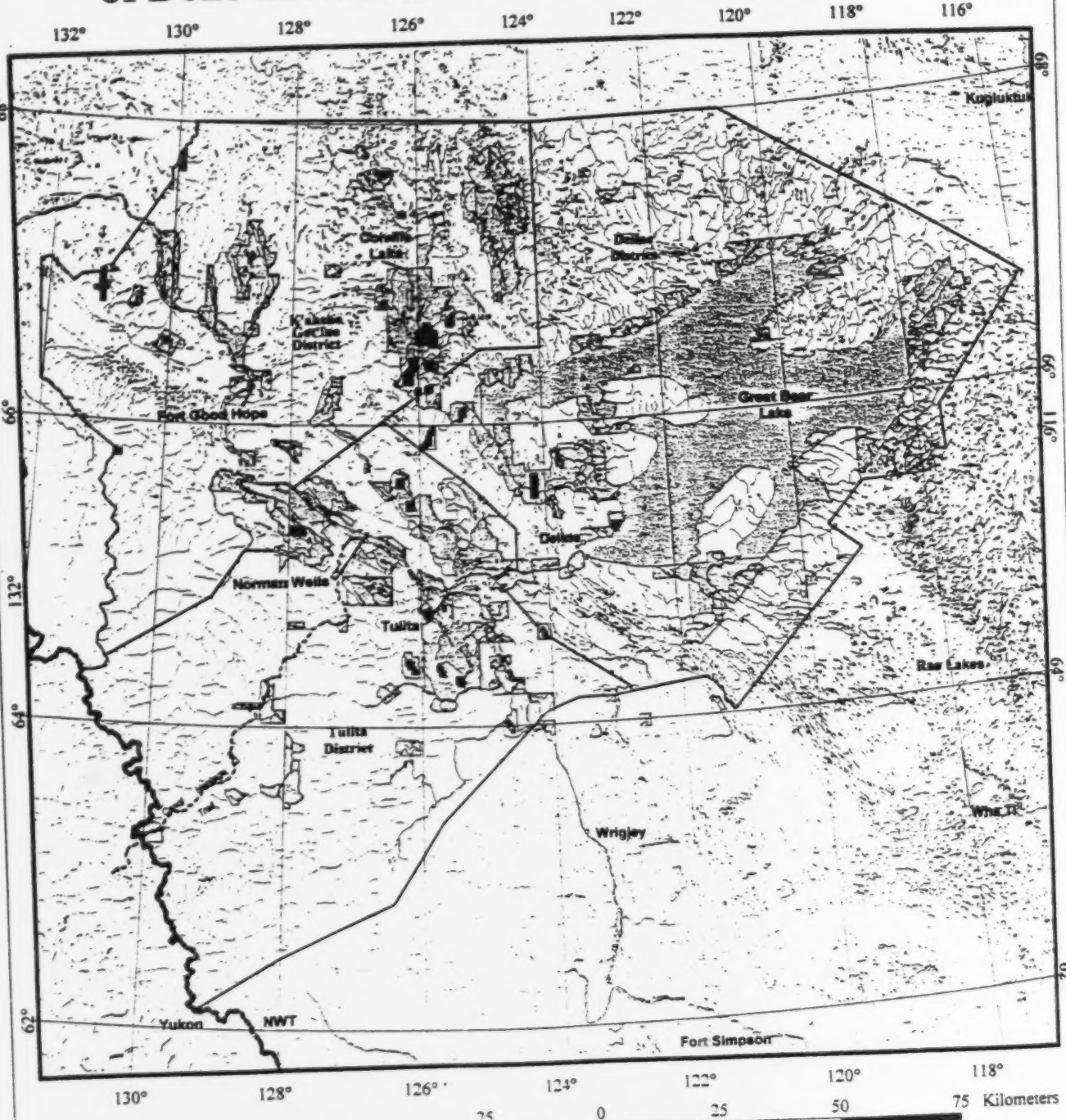
Sahtu Settlement Harvest Study - consulted Harvest Study Coordinator and the Harvest Study Working Group about options for mapping methods and design for this 5-year study of subsistence harvest needs of Sahtu Dene and Metis. Produced a set of 44 labeled 1: 250,000 maps for the Sahtu and adjacent regions where harvest by Sahtu Dene and Metis may occur. The maps were overlain by a 10 km by 10 km grid with each grid block identified by a unique number. The maps were laminated and collated into binders that will be used by the Harvest Study Community Interviewers to record harvest locations.

Sahtu Settlement Area Map Reference for the NTS 1:250,000 Scale Maps

Scale - 1:4,300,000 Projection - Lambert Conformal Conic Datum - NAD83

Prepared by the Sahtu Geographic Information System - April, 1998

Surface and Subsurface Rights of Dene and Metis in the Sahtu Settlement Area



THIS IS NOT A LEGAL DOCUMENT

Scale 1:4,200,000 Projection: Lambert Conformal Conic Datum: NAD83

Legend

- Surface land rights
- Surface and subsurface land rights
- Deline District
- Tulita District
- K'ahsho Got'ine District

Prepared by the Sahtu Geographic Information System

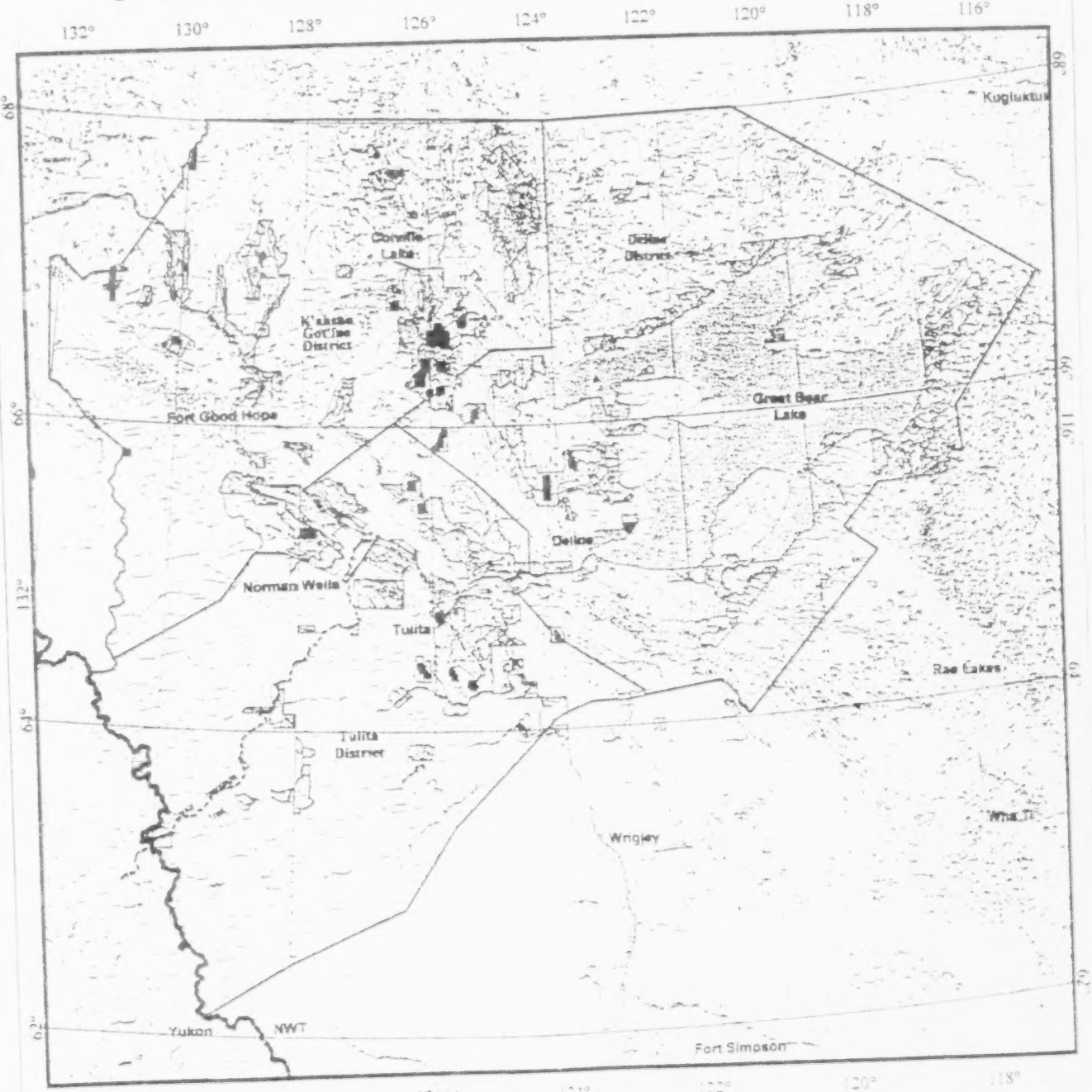
June 1998 For more information please call Lara at 867-587-2740

Sahtu Settlement Area Map Reference for the NTS 1:250,000 Scale Maps

Scale - 1:4,300,000 Projection - Lambert Conformal Conic Datum - NAD83

Prepared by the Sahtu Geographic Information System - April. 1998

Surface and Subsurface Rights of Dene and Metis in the Sahtu Settlement Area

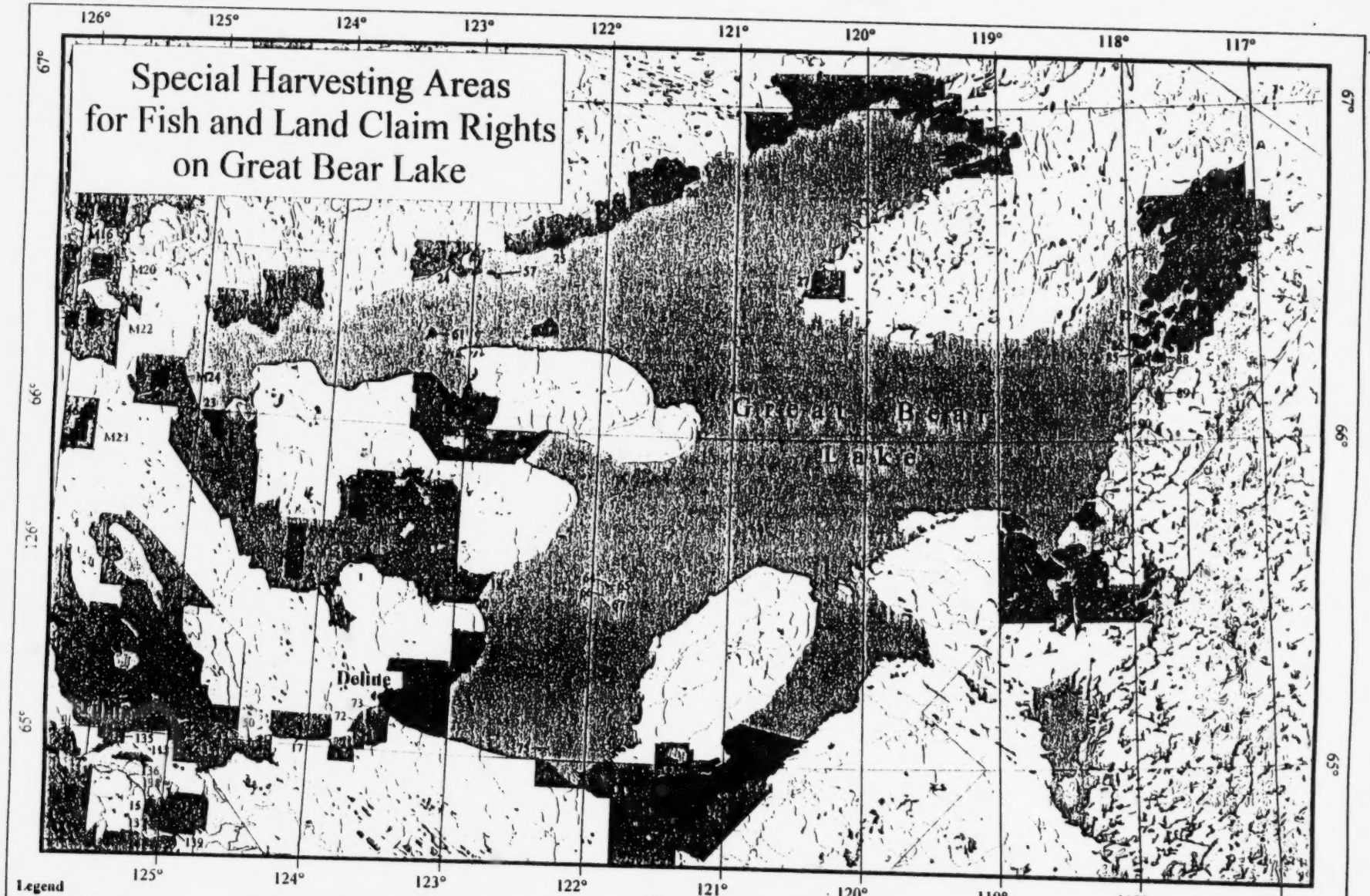


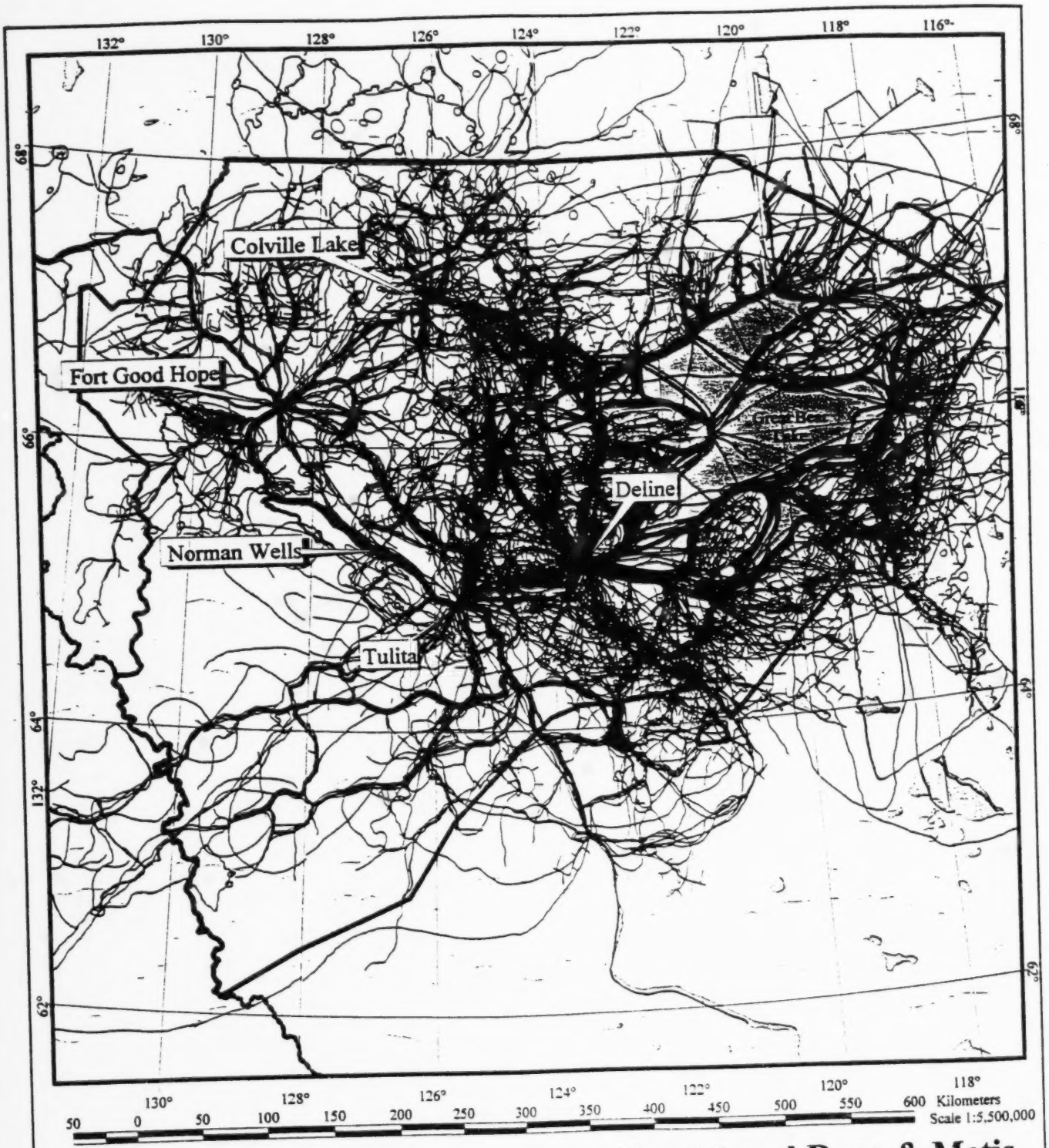
THIS IS NOT A LEGAL DOCUMENT

Legend

- Surface land rights
- Surface and subsurface land rights
- Deline District
- Tulita District
- K'ansho Got'ine District

Prepared by the Sahtu Geographic Information System


Special Harvesting Areas
for Fish and Land Claim Rights
on Great Bear Lake
Great Bear Lake
Deline
126°
125°
124°
123°
122°
121°
120°
119°
118°
117°
67°
66°
65°
Legend
Surface rights¹
Surface and Subsurface rights¹
Special harvesting areas for fish²
K'ahsho Got'ine District
Tulita District
Deline District
25 0 25 50 75 100 125 150 175 Kilometers
¹Parcel numbers as referred to in Appendix E, Volume II of the Sahtu Dene and Metis Comprehesive Land Claim Agreement
²Special harvesting area parcel numbers shown in this color Surface and subsurface parcel numbers shown in this color
³Pursuant to 13 4 4(a) persons who are not participants may only sport fish in accordance with legislation and no person, other than a person referred to in 13 7 3(c), may commercially harvest fish in the following areas (see map)
THIS IS NOT A LEGAL DOCUMENT
Contour Interval: 1000 feet
Scale 1:1,800,000
Projection: Lambert Conformal Conic
Datum: NAD83
Prepared by the Sahtu
Geographic Information System
March 1998. For more information please call Lane at 867-587-2740



Traditional Dene & Metis Trail Use in the Sahtu Settlement Area

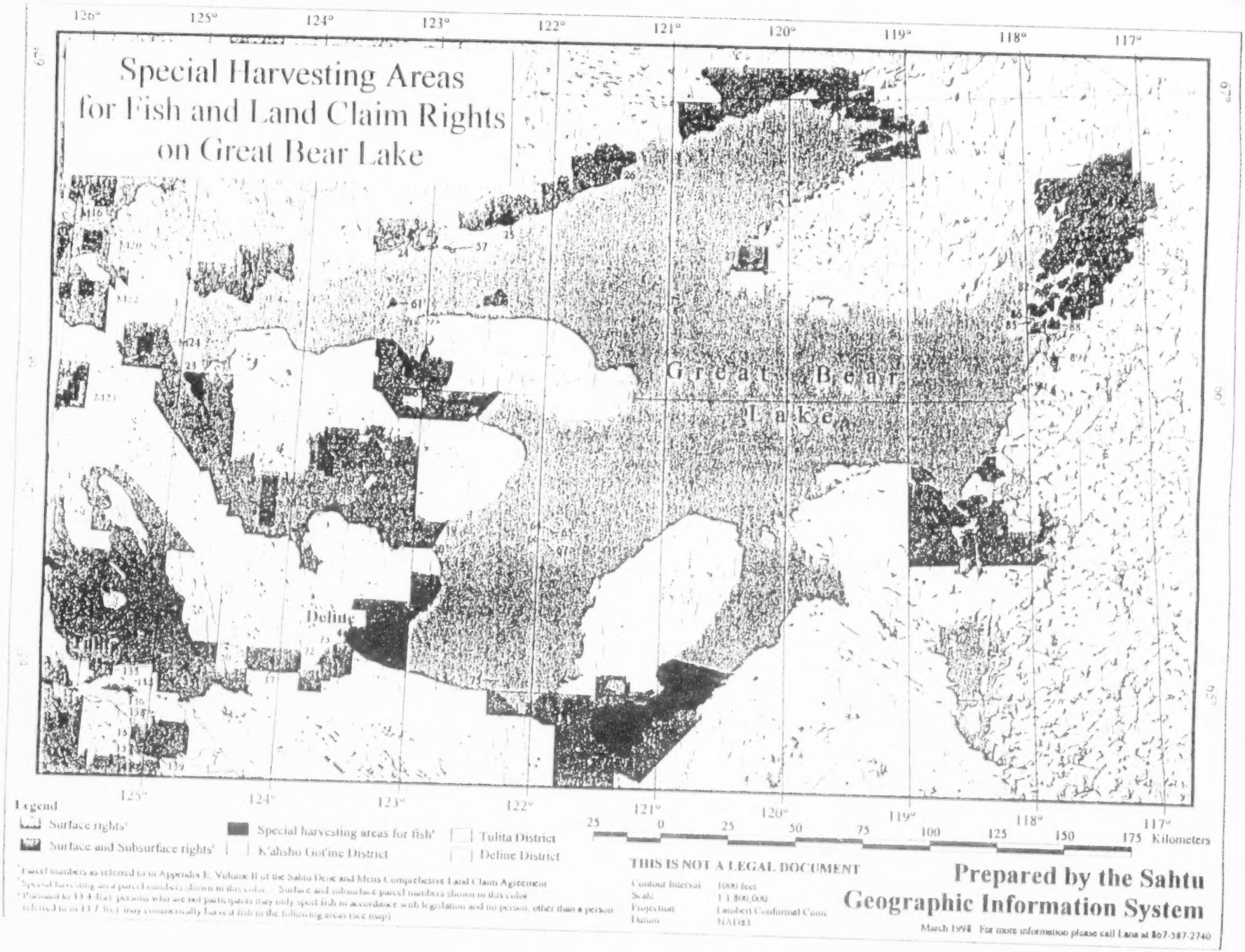
Legend

- Deline
- Tulita
- Fort Good Hope

This information was collected in the early 1970's. The trails contain information such as hunting, trapping, and other uses such as berry picking, as well as the type of travel on the trails.

THIS IS NOT A LEGAL DOCUMENT

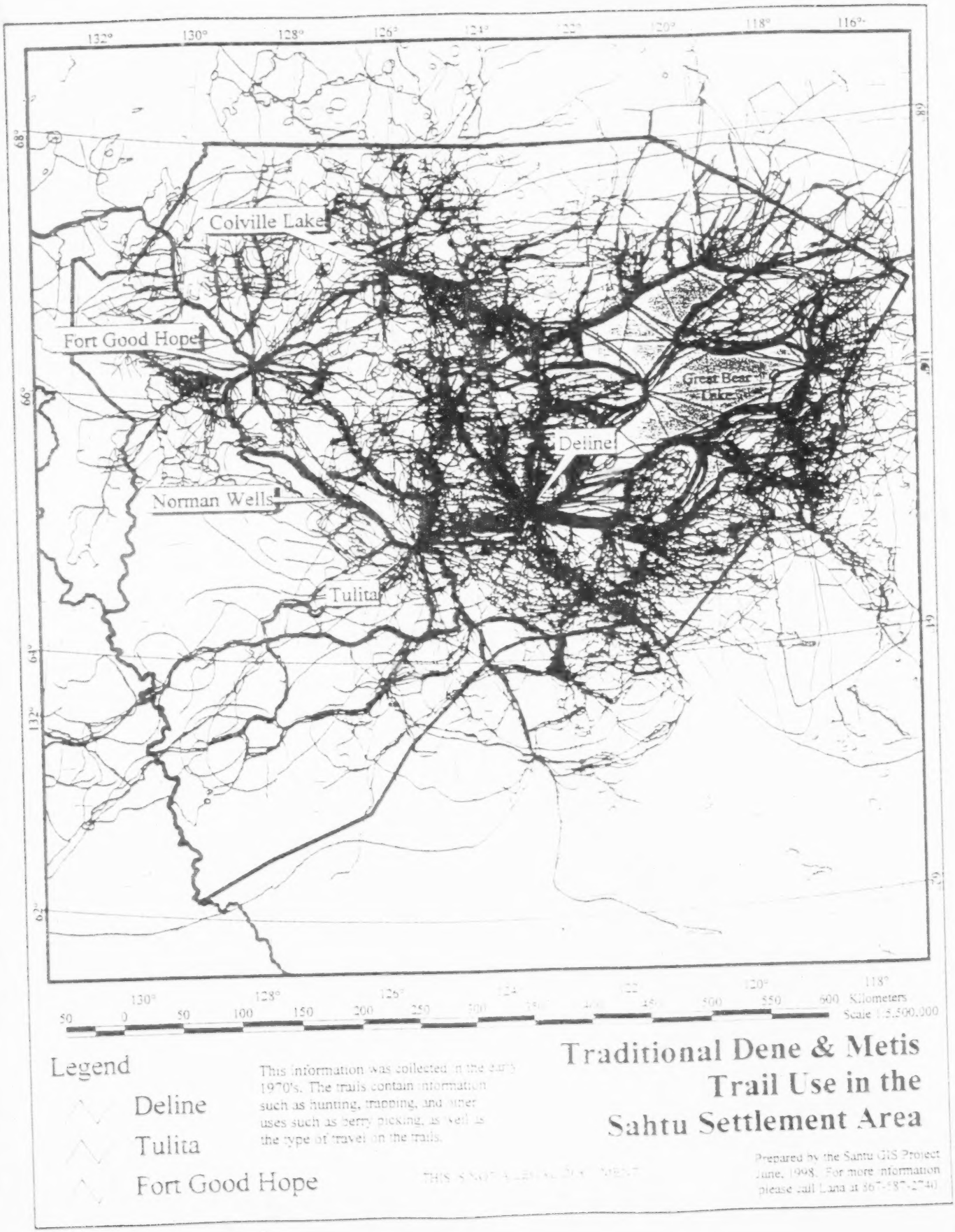
Prepared by the Sahtu GIS Project June, 1998. For more information please call Lana at 867-587-2740.

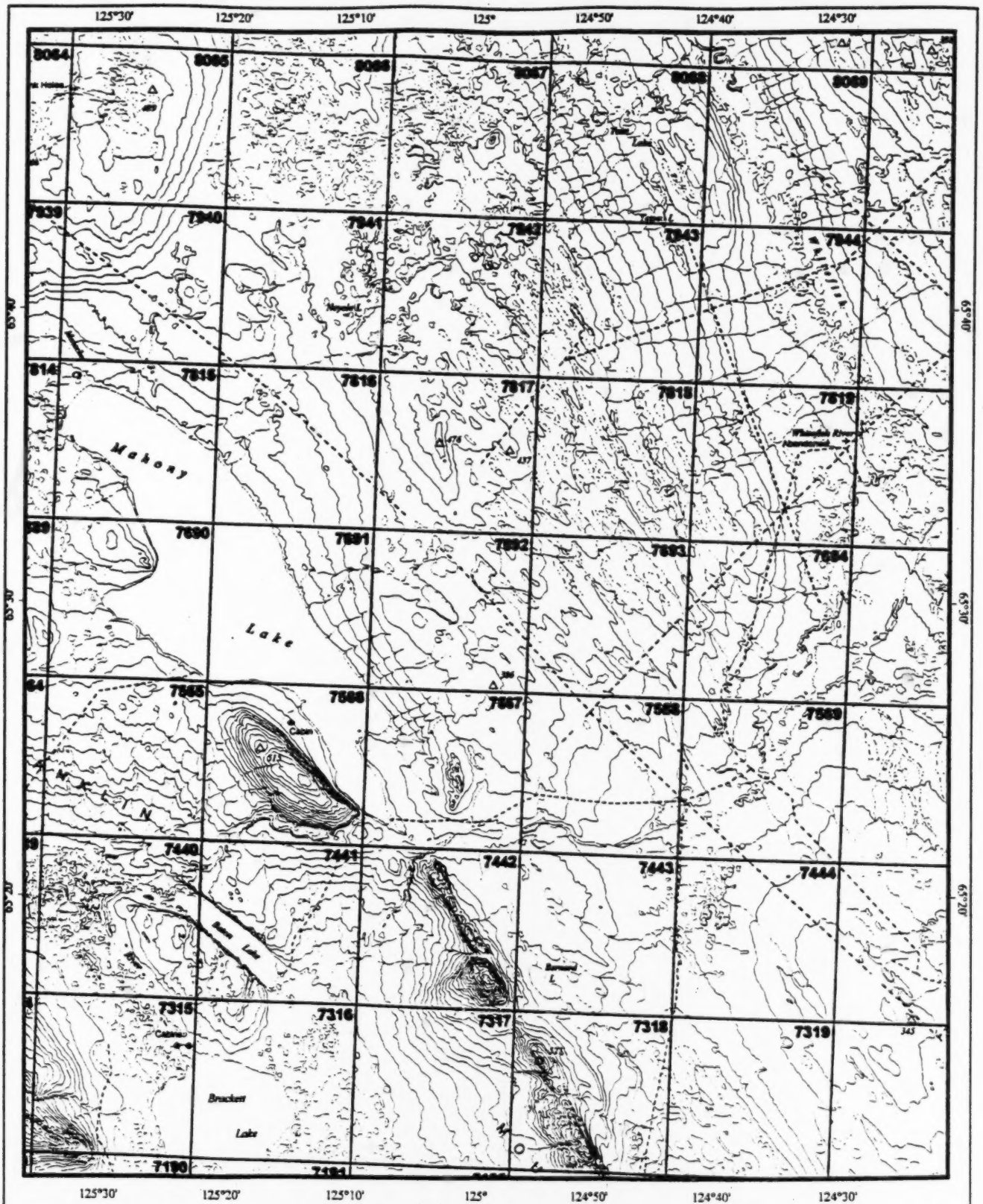


¹Parcel numbers as referred to in Appendix E, Volume II of the Sahtu Dene and Metis Comprehensive Land Claim Agreement

²Special harvesting area parcel numbers shown in this color. Surface and subsurface parcel numbers shown in this color.

³Pursuant to 13.4.8(a) persons who are not participants may only sport fish in accordance with legislation and no person, other than a person referred to in 13.7.3(c), may commercially harvest fish in the following areas (see map).


132°
130°
128°
126°
124°
122°
120°
118°
116°
68°
66°
64°
62°
Colville Lake
Fort Good Hope
Norman Wells
Tulita
Deline
Great Bear Lake
130°
128°
126°
120°
118°
50 0 50 100 150 200 250 500 550 600 Kilometers
Scale 1:5,500,000
Legend
Deline
Tulita
Fort Good Hope
This information was collected in the early 1970's. The trails contain information such as hunting, trapping, and other uses such as berry picking, as well as the type of travel on the trails.
Traditional Dene & Metis Trail Use in the Sahtu Settlement Area
Prepared by the Sahtu GIS Project June, 1998. For more information please call Lana at 867-587-2740



Example from the 'Sahtu Settlement Harvest Study Map Binder'

This shows the grid system that is used in the harvest study to locate monthly animal harvests. This is a five year study that will enable the calculation of minium needs for animal harvesting in the Sahtu Settlement Area.

LANDSAT TM Satellite Image Preparation – selected and purchased 7 images of the Sahtu and prepared them for use in the Vegetation Classification Project (see below).

Digital Elevation Models – purchased series of Digital Elevation Models from Geomatics Canada (Natural Resources Canada, Yellowknife) to be overlain on 1: 250,000 base maps.

Canol Heritage Trail and Dodo Canyon Territorial Park – organized and mapped data files received from Centre for Remote Sensing (DRWED, Yellowknife) of boundaries for the proposed Canol Heritage Trail and Dodo Canyon Territorial Park. Also overlaid the Canol Trail on LANDSAT TM satellite images.

North Great Bear Lake Muskox Survey - digitized March 1997 survey area and flight lines, plotted survey results, and produced maps for distribution and the survey report.

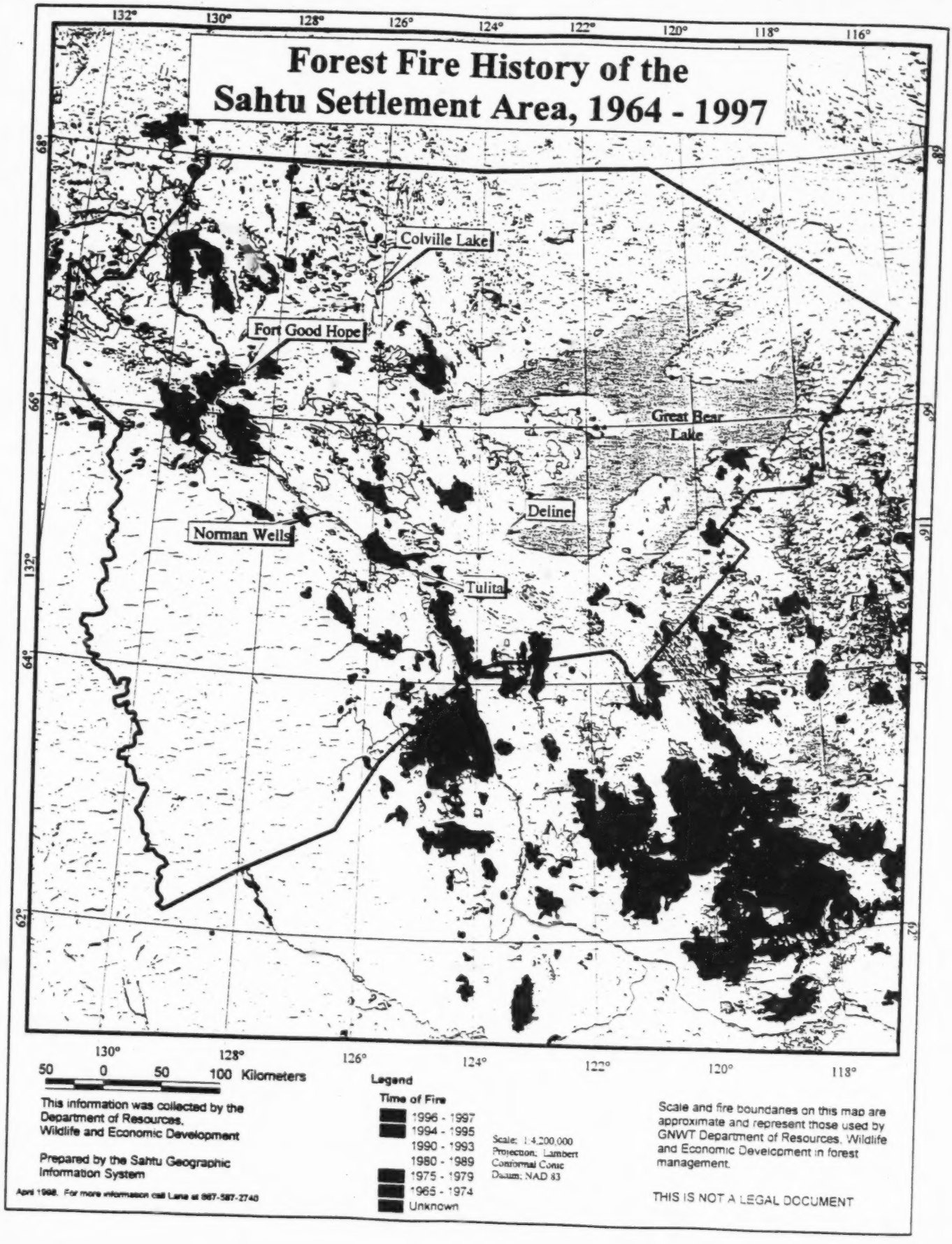
Fort Good Hope Area Moose Survey - digitized February 1998 survey blocks within the study area, prepared flight maps showing survey blocks, plotted and mapped results.

Forest Fire History – collected and organized data files received from Forest Management (Fort Smith) showing the location and year of all recorded forest fires within the Sahtu (1965-1997) and produced maps for distribution.

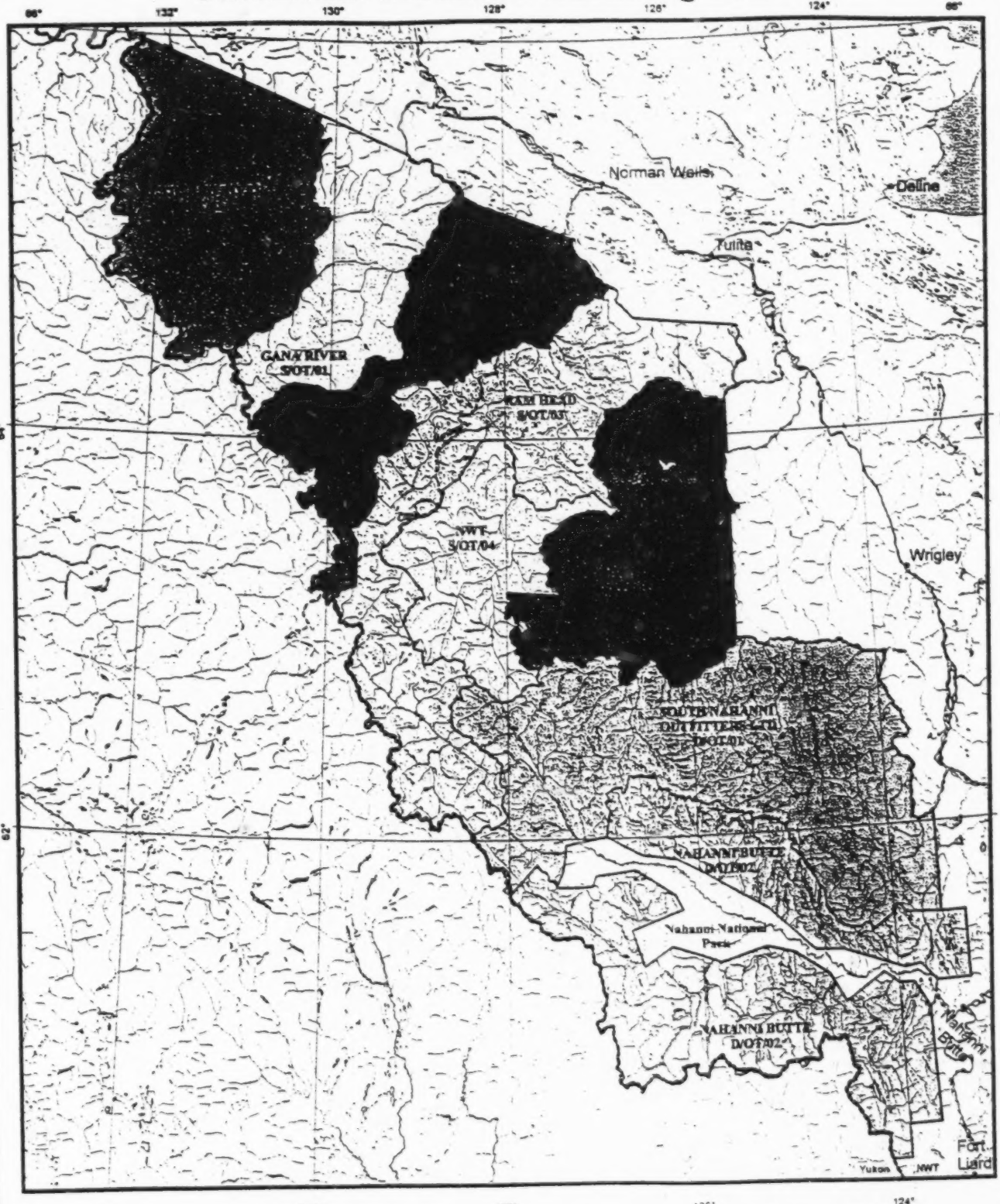
Geology – organized and mapped digital data files received from Natural Resources Canada (Geological Map of Canada CD-ROM, 1997) that show the main bedrock formations at or near the surface of the settlement area at 1: 5,000,000 scale.

Mackenzie Mountain Outfitting Zones – organized and mapped data files received from Centre for Remote Sensing (DRWED, Yellowknife) of boundaries for licenced big game non-resident and non-resident alien hunting zones in the Mackenzie Mountains, NWT. Also calculated the area of each zone.

Willow Lake Duck Banding Project – prepared base maps of the duck banding area with trap locations, camp sites, etc. Created a map of band returns (1995-1997) from across North America and a poster that shows the project location and band return maps, along with photographs taken of project activities and personnel. Maps distributed to the RRC's, SRRB, and the United States Fish and Wildlife Service, the project's principal funding organization.


Forest Fire History of the
Sahtu Settlement Area, 1964 - 1997
132°
130°
128°
126°
124°
122°
120°
118°
116°
68°
66°
64°
62°
Colville Lake
Fort Good Hope
Great Bear
Lake
Deline
Norman Wells
Tulita
50 0 50 100 Kilometers
Legend
Time of Fire
1996 - 1997
1994 - 1995
1990 - 1993
1980 - 1989
1975 - 1979
1965 - 1974
Unknown
This information was collected by the
Department of Resources,
Wildlife and Economic Development
Prepared by the Sahtu Geographic
Information System
April 1998. For more information call Lane at 867-587-2740
Scale: 1:4,200,000
Projection: Lambert
Conformal Conic
Datum: NAD 83
Scale and fire boundaries on this map are
approximate and represent those used by
GNWT Department of Resources, Wildlife
and Economic Development in forest
management.
THIS IS NOT A LEGAL DOCUMENT

Mackenzie Mountain Outfitting Zones



Legend

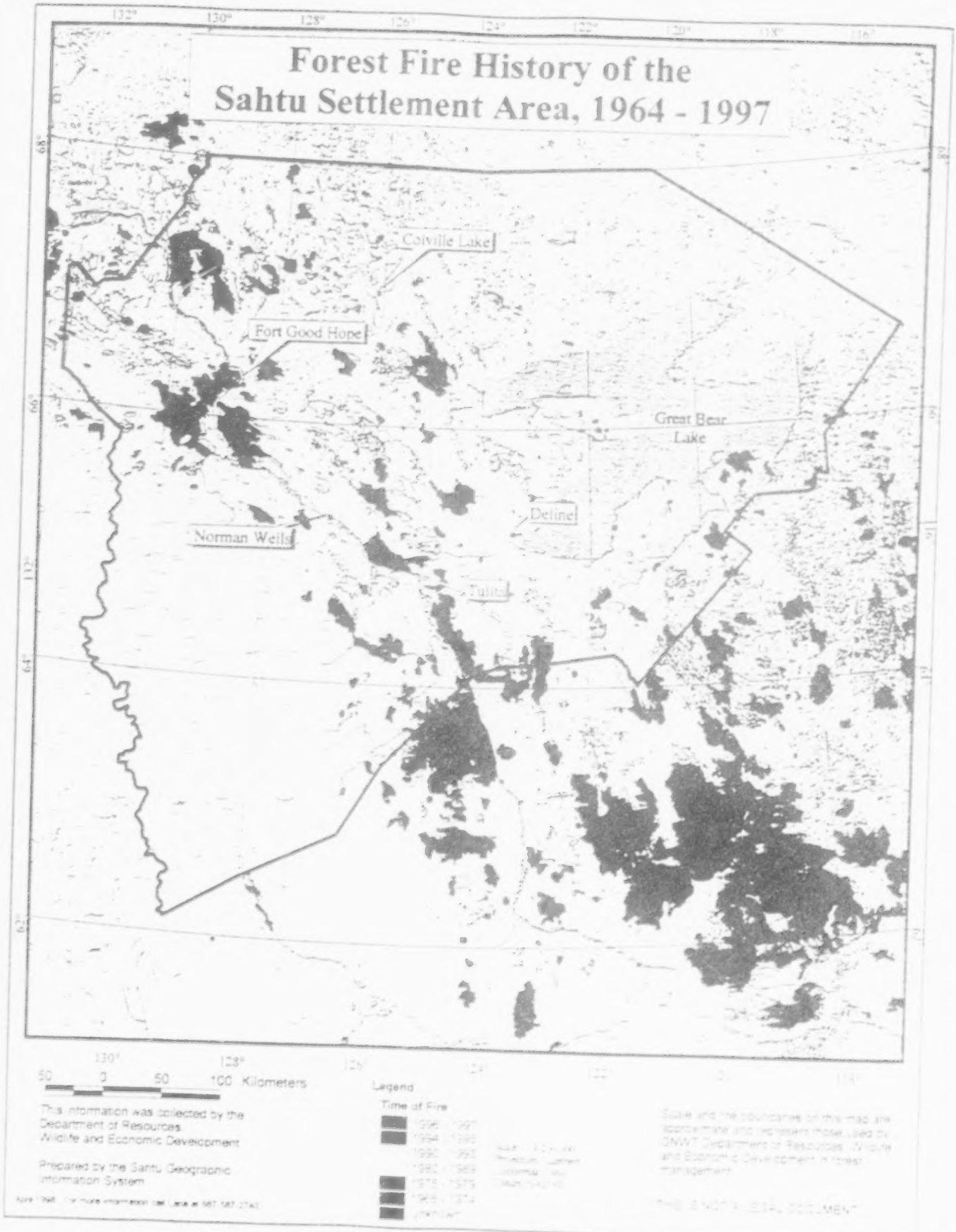
Outfitting Zones

Yukon & NWT Border

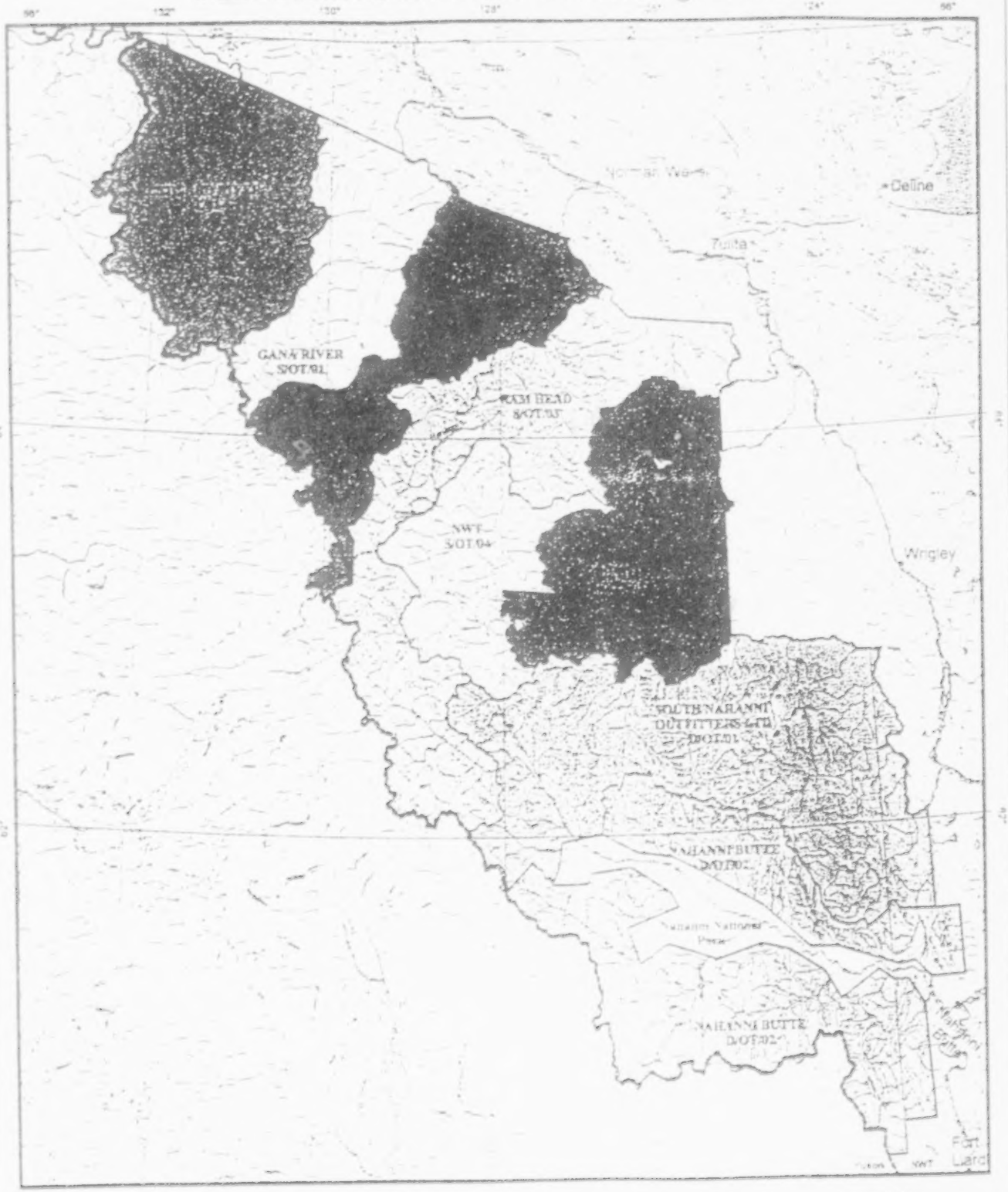
THIS IS NOT A LEGAL DOCUMENT

Contour Interval: 2000 feet
Projection: Lambert Conformal Conic

Prepared by the Sahtu
Geographic Information System

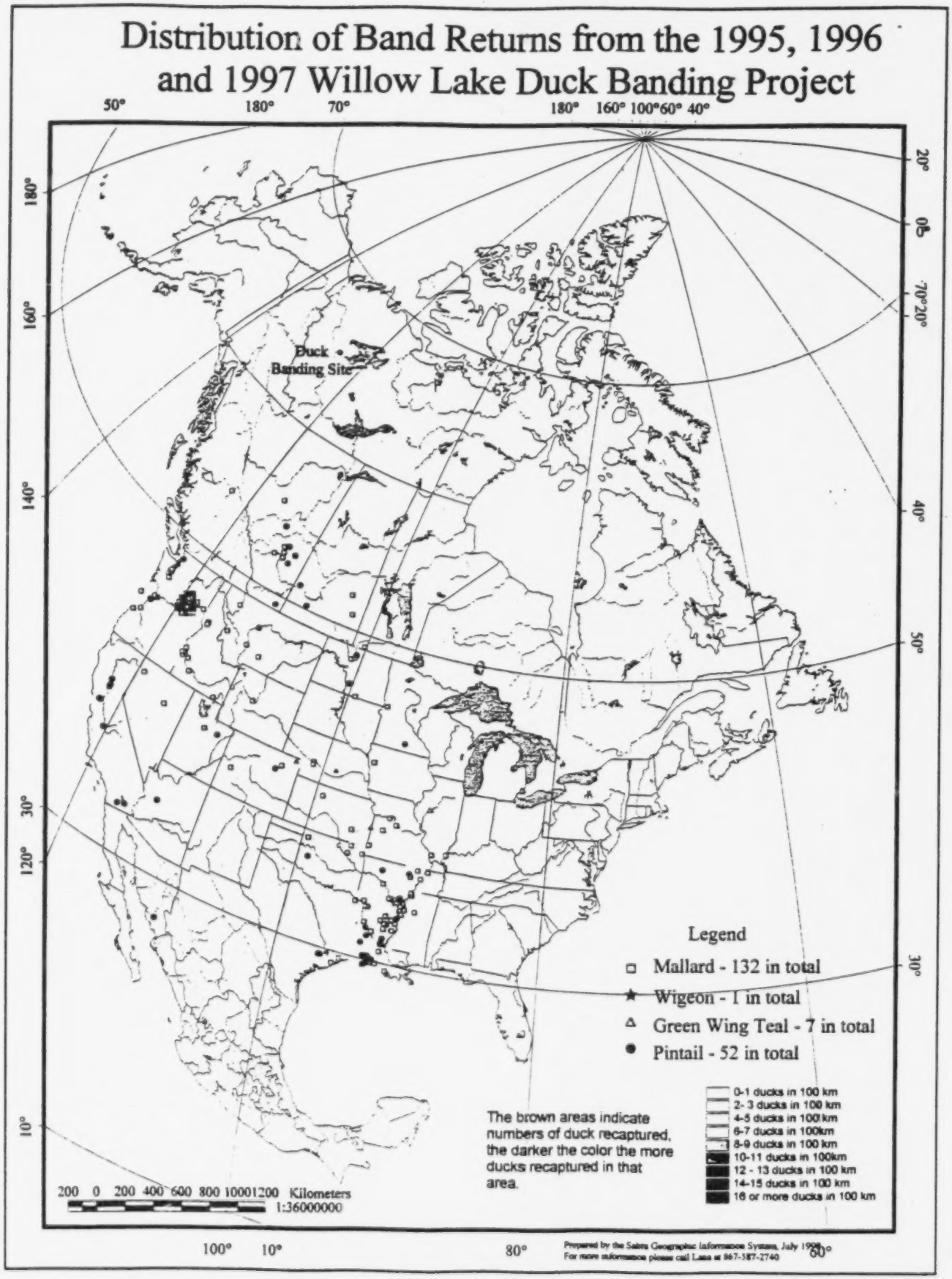

Forest Fire History of the
Sahtu Settlement Area, 1964 - 1997
Colville Lake
Fort Good Hope
Great Bear
Lake
Norman Wells
Deline
Tulita
132°
130°
128°
68°
66°
64°
62°
50 0 50 100 Kilometers
Legend
Time of Fire
This information was collected by the
Department of Resources,
Wildlife and Economic Development
Prepared by the Sahtu Geographic
Information System

Mackenzie Mountain Outfitting Zones



Prepared by the Sahtu
Geographic Information System

Distribution of Band Returns from the 1995, 1996 and 1997 Willow Lake Duck Banding Project


Duck Banding Site
Legend
Mallard - 132 in total
Wigeon - 1 in total
Green Wing Teal - 7 in total
Pintail - 52 in total
0-1 ducks in 100 km
2- 3 ducks in 100 km
4-5 ducks in 100 km
6-7 ducks in 100km
8-9 ducks in 100 km
10-11 ducks in 100km
12 - 13 ducks in 100 km
14-15 ducks in 100 km
16 or more ducks in 100 km
The brown areas indicate numbers of duck recaptured, the darker the color the more ducks recaptured in that area.
200 0 200 400 600 800 1000 1200 Kilometers
1:36000000
Prepared by the Sabin Geographic Information System, July 1998
For more information please call Lana at 867-387-2740

EXAMPLES OF WORK DONE FOR OTHER ORGANIZATIONS

Sahtu Secretariat Incorporated (September 1997) - Maps of Sahtu Settlement selected land parcels, forest fire history, and Special Harvesting Areas within the region.

Sahtu Land and Water Board (March 1998) - Maps of the Tulita, K'ahsho Got'ine, and Deline districts with Sahtu Settlement selected land parcels. Prepared a 1: 1,000,000 scale reference map of the three districts, showing the identification number and location of 1: 250,000 NTS maps within the Sahtu. Also advised staff on desktop GIS hardware and software specifications.

Deline District Land Corporation (September, October, November 1997; February and May 1998) - Mapped the 'restriction of public use of portages and waterfront lands on Sahtu lands' (schedule VIII, Appendix E of the Sahtu Land Claim). Map included restricted areas, Special Harvesting Areas, and Sahtu Settlement selected land parcels within the Deline District. Also produced maps of the Sahtu Settlement selected land parcels.

Tulita District Land Corporation (September 1997 and May 1998) – 1: 250,000 maps, large posters, and wall displays of Sahtu Settlement selected land parcels (including parcel numbers) and Special Harvesting Areas in the Tulita District.

Deline Dene Band (March 1998) - Map of Sahtu Settlement selected land parcels.

Deline Renewable Resources Council (March 1998) - Maps of Sahtu Settlement selected land parcels around Grizzly Bear Mountain National Historic Site.

Great Bear Lake Advisory Group (May 1998) - Maps of Sahtu Settlement selected land parcels around Great Bear Lake and Special Harvesting Areas on the lake.

NWT Community Mobilization Partnership (March 1998) - Large maps of Sahtu Settlement selected land parcels and outfitting zones in the Mackenzie Mountains, NWT.

Town of Norman Wells (November 1997) - Mapped area within 30 km of the community showing lakes, rivers, municipal boundaries, and the Canol Heritage Trail. The map was used in a brochure to give to tourists coming to Norman Wells.

Norman Wells Business Development Corporation (March 1998) - Topographic map of the Sahtu showing community locations, rivers, lakes, and contour intervals.

Golder Associates (Environmental Consultants, Calgary Alberta) (October 1997) - Prepared roadway maps to three Ranger Oil Ltd. oil drilling sites in the Tulita District, and the actual drill sites. The maps were used in Golder's environmental impact assessment of the Tulita Exploratory Drilling Project (Golder Associates, 1997).

Association of Mackenzie Mountain Outfitters (April 1998) – Maps showing licenced big game hunter outfitting zones in the Mackenzie Mountains, NWT.

STEERING COMMITTEE

The various individuals and groups currently involved in the project, and those that may be included in future, each have their own priorities for incorporating data into the GIS and desired uses of the system. Therefore, we need to have consensus on the data that are to be obtained and a time scale for its acquisition. We suggest that a GIS Project Steering Committee should be formed with representation from each of the Sahtu co-management boards and the GNWT regional office. The formation and functions of this committee should be discussed at the August 1998 GIS Project meeting.

We envision that each of the co-management boards contributing to core funding for the GIS Project and participating on the Steering Committee will set up their own 'desktop' GIS station. These stations will run *ArcView* software with data layers provided by the 'professional' GIS Project. This will allow each board to produce their own custom-made maps. Training in the use of *ArcView* and the desktop station can be provided to staff with each co-management board (or other organizations in the region interested in acquiring GIS capability) by the GIS Specialist. The GIS Specialist can also assist with setting up the appropriate databases for each co-management board. In Appendix 3 we provide an overview of system hardware, software, and approximate costs for a 'desktop' GIS station.

PROJECT BUDGET: 1998/99 TO 2001/02

The following is an itemized list of the core funding costs of the Sahtu GIS Project for the current fiscal year and the next three years. These costs should be shared by the co-management boards within the Sahtu and the GNWT.

Item	1998-1999	1999-2000	2000-2001	2001-2002	Total
ARC/INFO annual site licence	5,500	5,500	5,500	5,500	$22,000
ER Mapper annual site licence	1,000	1,000	1,000	1,000	$4,000
ARC GRID annual site licence	1,000	1,000	1,000	1,000	$4,000
ARC TIN purchase and annual site licence		2,000	1,000	1,000	$4,000
Computer hardware		3,000	1,000	3,000	$7,000
Computer software	750	750	750	750	$3,000
GIS Specialist salary and benefits	59,000	60,500	63,000	64,500	$247,000
Part time GIS technician, trainee		20,000	21,500	23,000	$64,500
Texts, manuals, & journals	500	500	500	500	$2000
Travel expenses	5,000	5,000	5,000	5,000	$20,000
Office supplies	2,000	2,000	2,000	2,000	$8,000
TOTAL	$74,750	$101,250	$102,250	$107,250	$385,500

Budget Rationale:

ARC/INFO site licence - annual site licence permits us to operate the system, provides access to technical support, and provides any software upgrades.

ER Mapper site licence - as per *ARC/INFO*.

ARC Grid- allows modelling and analysis with raster data.

ARC Tin- allows 3-dimensional mapping and modelling of the digital elevation model data.

Computer Hardware and Software - purchase of hardware and software upgrades as necessary and costs for occasional hardware alterations and repairs.

GIS Specialist Salary and Benefits - salary equivalent to pay level 27 on the GNWT scale. Benefits include a $5400 annual northern allowance in addition to base salary.

Part – time GIS technician (trainee position) - half time assistant for the GIS specialist, to assist with map production, and data preparation.

Manuals, Texts, and Journals - GIS is a discipline that continues to grow and develop at a rapid pace. Therefore, it is essential that the project have access to the latest texts, manuals, and periodic journals of the field in order to keep abreast of those developments and procedures.

Travel – to communities for training and desktop GIS set up, to Fort Smith (Forest Management), Yellowknife (e.g., Centre for Remote Sensing), Inuvik (DRWED and Gwich'in and Inuvialuit co-management boards), etc.

Office Supplies - plotter paper costs ca. $75 per roll and plotter pens are $50 - $60 per pen (4 colours). Other basic office supplies will be supplied as required by DRWED.

REFERENCES

Aronoff, S. 1989. GIS: a management perspective. WDL Publications, Ottawa, ON. 294 pp.

Crockett, M. 1997. GIS companies race for market share. GIS World 10(11): 54-57.

Golder Associates. 1997. An environmental field survey of the Tulita exploratory drilling project. Technical Report Submitted to Ranger Oil Ltd, Calgary, AB. 27 pp.

Franklin, J. F. 1994. Developing information essential to policy, planning, and management decision making: the promise of GIS. pp. 18-24 *in* V. A. Sample, ed. Remote sensing and GIS in ecosystem management. Island Press, Washington, DC. 369 pp.

Koeln, G., L. M. Cowardin, and L. L. Strong. 1994. Geographic information systems. Pp. 540-556 *in* T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. Fifth ed. The Wildlife Society, Bethesda, MD. 740 pp.

Lanoville, R. 1997. Vegetation classification using TM LANDSAT imagery. Unpubl. Workshop Report, Forest Management Division, Dept. of Resources, Wildlife, & Economic Development, Fort Smith, 6-8 May, 1997. 2 pp.

Lewis, D. M. 1995. Importance of GIS to community-based management of wildlife: lessons from Zambia. Ecol. Appl. 5(4): 861-871.

Morrison, R.I.G. 1997. The use of remote sensing to evaluate shorebird habitats and populations on Prince Charles Island, Foxe Basin, Canada. Arctic 50: 55-75.

Veitch, A. 1996. Sahtu Settlement Area GIS Mapping Project. Unpubl. Project Outline Prep. for the Sahtu Renewable Resources Board, Norman Wells, 01 October. 1996. 13 pp.

APPENDIX 1. Project Expenditures: 1997/98 and 1998/99

A) 1997/98 - $232, 390

Department of Resources, Wildlife, and Economic Development, GNWT - $166,990

- $5,000 contributed by Wildlife Management Division, Norman Wells.
- $78,356 contributed by Forest Management Division, Norman Wells for Vegetation Classification Project.
- $51,734 contributed by Forest Management Division, Fort Smith for staff to perform vegetation classification, and a general contribution.
- $31,900 contributed by the Sahtu Region, GNWT Implementation funding for hiring of an assistant, purchase of a Polaroid slide maker, office space, and fax, phone use.

Sahtu Renewable Resources Board - $65,400

- $65,400 Contributed for GIS specialist salary

B) 1998/99 - $ to be determined

Department of Resources, Wildlife, and Economic Development, GNWT - $ to be determined

- $5,000 contributed by Wildlife Management Division, Norman Wells
- $? contributed by Forest Management Division, Norman Wells (final amount to be determined).
- $? contributed by Forest Management Division, Fort Smith (final amount to be determined).

Sahtu Renewable Resources Board

- $60,000 contributed for general project costs.

APPENDIX 2. VEGETATION CLASSIFICATION PROJECT

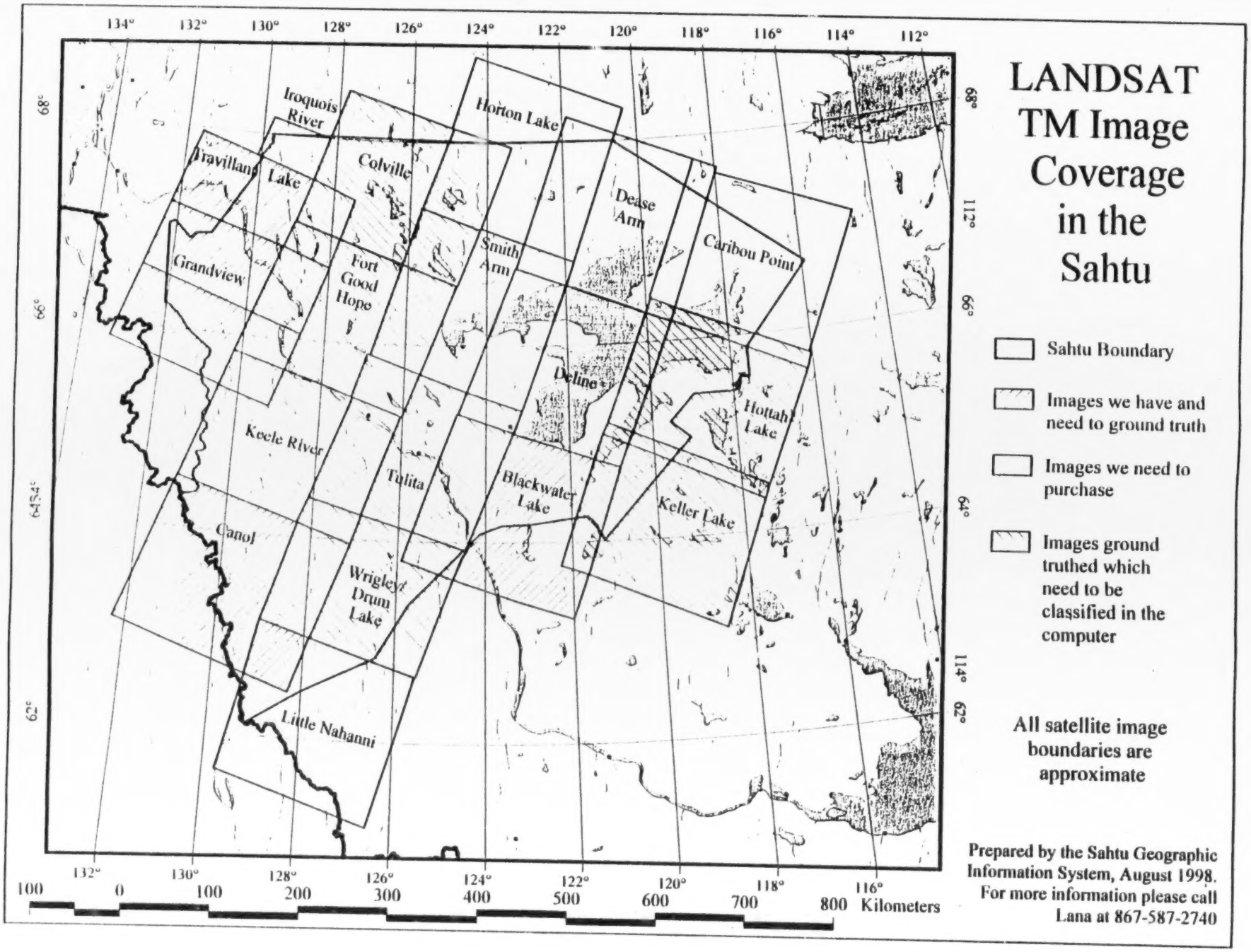
Item	1998-1999	1999-2000	2000-2001	2001-2002	Total
Vegetation Classification Project	$115,500	$82,000			$197,500

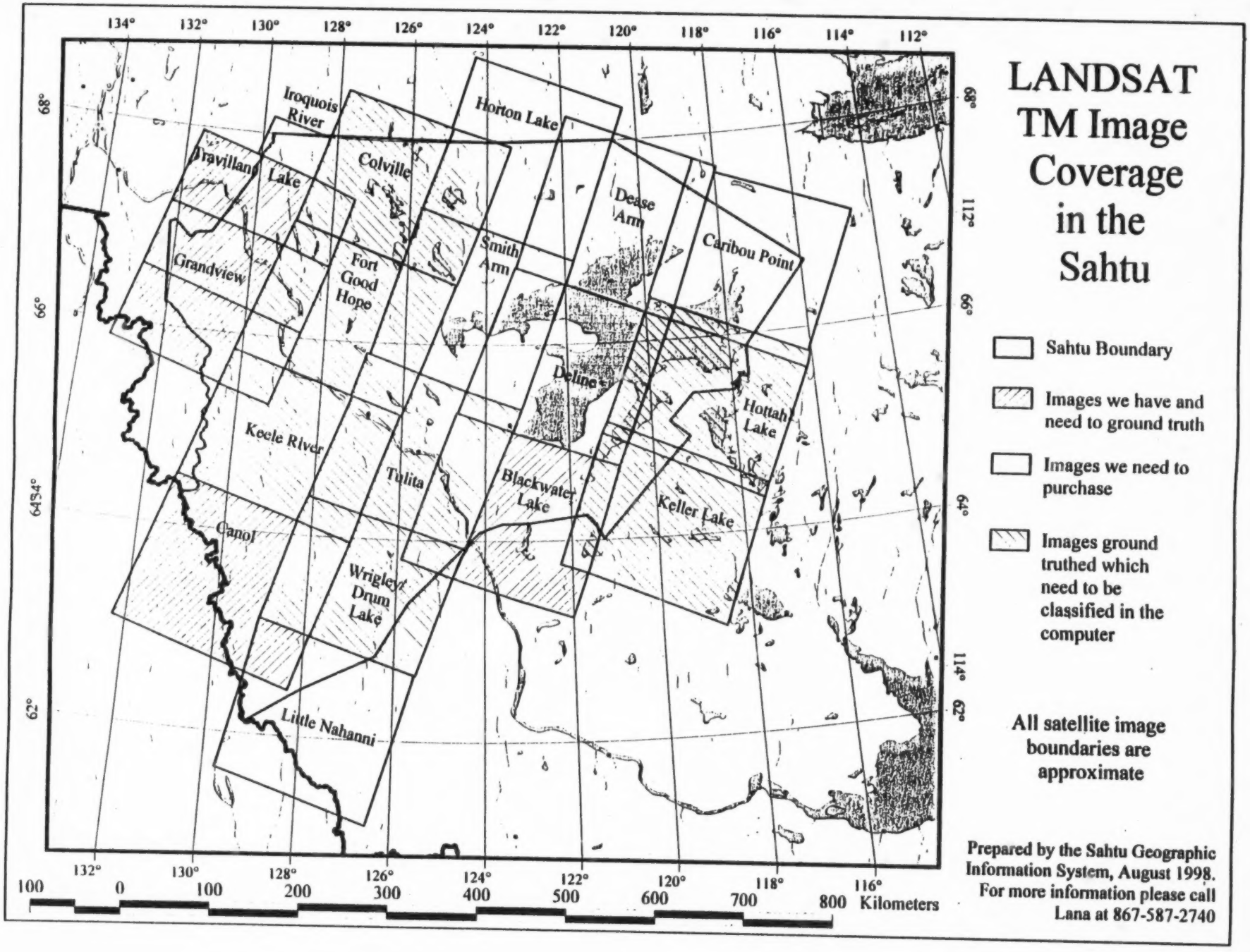
Vegetation Classification – includes purchase of 5 more LANDSAT TM images, hiring casual staff, and associated costs ($16,500 per image total cost).

Knowledge of the types and distribution of the different habitats that occur within the Sahtu is essential for land, forestry, and wildlife management; therefore, we require a complete vegetation classification map. This is the most labour-intensive and expensive aspect of the GIS Project.

Vegetation classification has been done with aerial photography, satellite imagery, or both. Aerial photography is commonly used in forest management because of its high resolution (i.e., detail). However, it would take at least 10,000 aerial photos to cover the Sahtu and the huge cost to acquire those is prohibitive. Satellite images are simply another form of aerial photograph taken by satellites that orbit 700 km above the Earth. Colours on satellite images result from differential light reflection from objects on the ground - the reflection from a spruce tree is different from that from a grass meadow; therefore, they appear as different colours on the satellite image. With appropriate software and field work, a computer can be used to classify vegetation based on these different reflectance values.

One of the most commonly used satellites for taking images is the LANDSAT Thematic Mapper (TM). Early in the project's development we identified LANDSAT TM images as the most suitable for the project due to their long history (available since 1972), commercial availability, resolution (30 m by 30-m pixel size), and widespread use across Canada and the rest of the world. Each LANDSAT image covers an area of approximately 180-km by 180 km (i.e., 32,000 km^2).


LANDSAT
TM Image
Coverage
in the
Sahtu
Sahtu Boundary
Images we have and need to ground truth
Images we need to purchase
Images ground truthed which need to be classified in the computer
All satellite image boundaries are approximate
Prepared by the Sahtu Geographic Information System, August 1998.
For more information please call Lana at 867-587-2740
Iroquois River
Horton Lake
Travillan
Lake
Colville
Dease Arm
Caribou Point
Smith Arm
Grandview
Fort Good Hope
Deline
Hottah Lake
Keele River
Tulita
Blackwater Lake
Keller Lake
Canol
Wrigley
Drum Lake
Little Nahanni
134°
132°
130°
128°
126°
124°
122°
120°
118°
116°
114°
112°
68°
66°
64°
62°
100 0 100 200 300 400 500 600 700 800 Kilometers


LANDSAT
TM Image
Coverage
in the
Sahtu
Sahtu Boundary
Images we have and need to ground truth
Images we need to purchase
Images ground truthed which need to be classified in the computer
All satellite image boundaries are approximate
Prepared by the Sahtu Geographic Information System, August 1998.
For more information please call Lana at 867-587-2740
Iroquois River
Horton Lake
Travillant Lake
Colville
Dease Arm
Caribou Point
Smith Arm
Grandview
Fort Good Hope
Deline
Hottah Lake
Keele River
Tulita
Blackwater Lake
Keller Lake
Canol
Wrigley
Drum Lake
Little Nahanni
134° 132° 130° 128° 126° 124° 122° 120° 118° 116° 114° 112°
68° 66° 64°34' 62°
100 0 100 200 300 400 500 600 700 800 Kilometers

In Canada, *Radarsat International* is the sole supplier for LANDSAT TM images. Leverington visited their Canadian office in Burnaby, BC in December 1996 to look for a complete set of images for the Sahtu that met the following specifications: taken between 08 June and 07 August (i.e.. while vegetation in 'full leaf'), no more than 5% total cloud cover, and taken between 1992 and 1996. A set of 17 full and 4 partial images that met these criteria was selected. The first 5 of those images on CD-ROM were purchased by the SRRB in March 1997 and two more images were purchased by RWED in February 1998 (Appendix 2).

Vegetation classification from LANDSAT TM images commonly exceeds 75% accuracy and can exceed 90% in some situations (Morrison 1997). The process we are using involves:

- *preparation of the image* –

  geo-reference using 1: 250,000 scale NTS base maps

  select appropriate 3 wavelength bands to highlight differences in vegetation types

  enhance each selected band to maximize colour differences

  print image at 1: 100,000 for selection of ground-truthing sites
- *selection of ground – truthing sites* – approximately 150 sites are selected for each image based on homogenous patches of colour.
- *ground-truthing* - identifying the type of vegetation that exists at the sites from helicopter or fixed-wing aircraft.
- *supervised classification of the image* - taking ground truthing information to assign vegetation classes to groups of pixels with similar reflectance values.

A critical component of classifying vegetation from the LANDSAT TM images is first to determine how many classes (categories) of vegetation are needed. In early May 1997, a workshop on vegetation classification using LANDSAT TM imagery was hosted by Forest Management in Fort Smith and was attended by GIS and remote sensing specialists with the Gwich'in and Sahtu co-management boards, the Centre for Remote Sensing (DRWED, Yellowknife), Alberta Lands and Forest, and Wood Buffalo National Park. At this workshop the

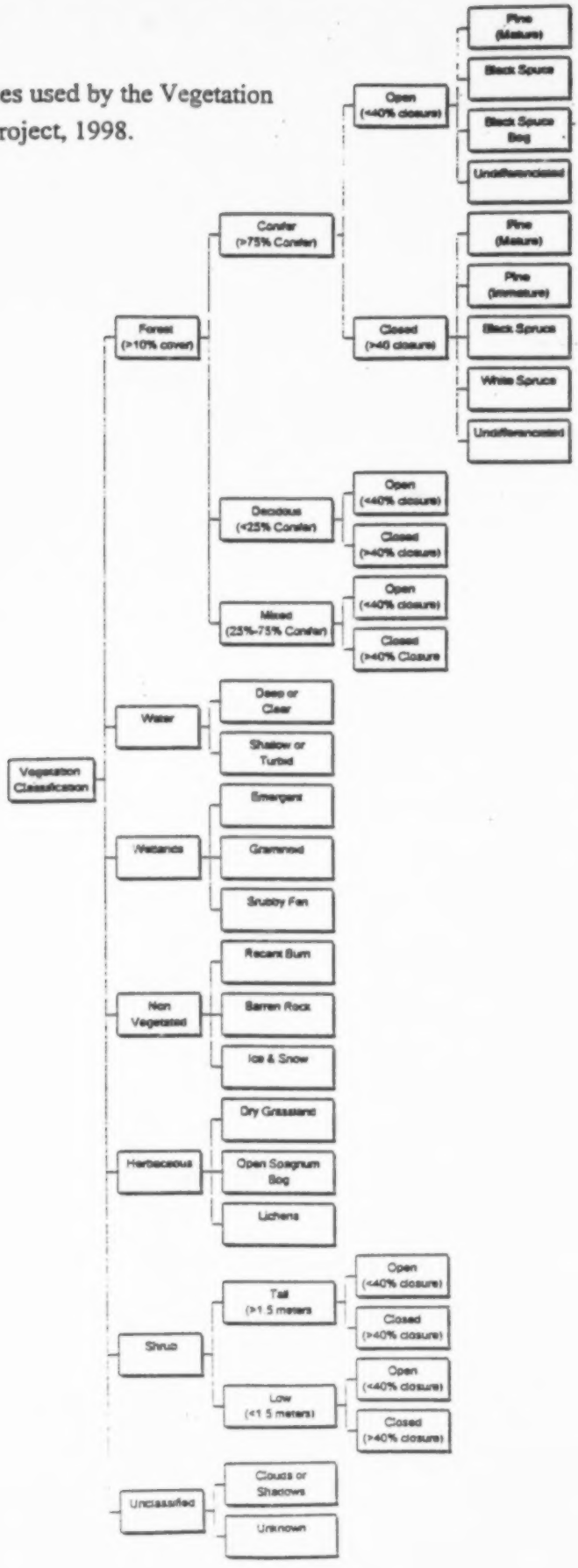
participants drafted *NWT Vegetation Classification Guidelines for TM LANDSAT Imagery*, which included identifying a list of common vegetation cover classes (Appendix 3) and a protocol for ground-truthing the satellite images (Lanoville, 1997).

The satellite image classification software recommended by Forest Management (Fort Smith) for the project is *ER MAPPER* 5.0. A copy of this software was purchased by the SRRB in May 1997. We have since updated to *ER MAPPER* 5.5.

In May-August 1997, a Ph.D. graduate student (University of Alberta) was hired by the SRRB with funds provided by a contract with Forest Management (Fort Smith) to assist with setting up the Vegetation Classification Project. Between June and August 1997 training sites on two images were selected and flown in helicopter and fixed-wing aircraft. Unfortunately, since methods differed from protocol identified at the image classification workshop in Fort Smith, the results were not suitable for the project's requirements.

In 1998 two casual staff were hired by DRWED for the Vegetation Classification Project (May-August). These staff were provided with extensive ground and aerial training by staff from Forest Management (Fort Smith) to ensure compliance with the protocol established in May 1997. These staff chose training sites, prepared flight plans, arranged aircraft, and performed the aerial classification of training sites. By the end of July 1998, all training sites in four images had been flown and three additional images were prepared for flying in August. Prior to the 1999 summer field season, the GIS Specialist will do a supervised classification of those images and an accuracy assessment for each (this will take about three weeks per image).

Vegetation classes used by the Vegetation Classification Project, 1998.



APPENDIX 3: Approximate costs of setting up 'desktop' GIS in each co-management board

The following is an itemized list of the costs of the 'desktop' GIS that we have installed in the Sahtu GIS Project office. The costs are approximate, due to the ever-changing nature of the computer industry.

Item	cost
Computer	$6,000
ArcView GIS software	$1,700
Microsoft Office Pro	$500
Colour printer	$1,200
Total approximate cost	$9,400

Requirements:

Computer - (minimum requirements: 17 inch monitor, *Pentium Pro II*, 64 MB RAM, 4 GB hard drive, 16x speed CD ROM, 4 MB video card. Recommended requirements: 21-inch monitor, 128 RAM, 8 GB hard drive, writeable CD ROM drive, 8 MB or higher video card.

ArcView - 'desktop' GIS software

Microsoft Office Pro - contains *Word, Excel*, and *Access*

Colour Printer - we purchased an *Epson 1520* printer, but any brand that is able to print 14" x 22", or 17" x 22" inch is good.

Optional :

Polaroid 6000 slide maker

HP Designjet Plotter – for printing up to 34" x 44"

Lamination machine

UPS power back up system